

ARMY RESEARCH LABORATORY



# Improvements to the U.S. Army Research Laboratory (ARL) Army Unit Resiliency Analysis (AURA) "All Clear" Algorithm

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ARL-TR-978

March 1996

19960318 049

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project(0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE March 1996	3. REPORT TYPE AND DATES COVERED Final, April - July 95		
4. TITLE AND SUBTITLE Improvements to the U.S. Army Research Laboratory (ARL) Army Unit Resiliency Analysis (AURA) "All Clear" Algorithm		5. FUNDING NUMBERS  665604		
6. AUTHOR(S) Richard L. zum Brunnen				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory ATTN: AMSRL-SL-CM Aberdeen Proving Ground, MD 21010-5423		8. PERFORMING ORGANIZATION REPORT NUMBER  ARL-TR-978		
9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)		10. SPONSORING/MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT  Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words)  The Project Manager for the Corps Surface-to-Air Missile (PM CORPS SAM) is planning to use the U.S. Army Research Laboratory's (ARL) Army Unit Resiliency Analysis (AURA) model to assess the weapon system's performance. Part of the effort included a review of modifications made to AURA by PM CORPS SAM's contractor MEVATEC. This report is a result of the review of MEVATEC's "All Clear" algorithm used in determining when personnel can remove mission-oriented protective posture (MOPP) gear.				
14. SUBJECT TERMS  AURA, MOPP, "All Clear," chemical, algorithm			15. NUMBER OF PAGES 18	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

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## 1. INTRODUCTION

The Ballistic Missile Defense Organization, in its 1994 Report to Congress, noted the following:

Currently, mature design Theater Ballistic Missiles (TBMs) are extensively deployed, and, because of their low cost and availability, they are proliferating throughout the world. . . . Adding to the threat complexity are the various warheads including high explosives, bulk or submunitions, and weapons of mass destruction (nuclear, biological, and chemical). The TBM allows the enemy, who formerly had to fly over the intended target in order to deliver their payload, to stand off at a safe range of hundreds of kilometers. Desert Storm demonstrated the difficulty of identifying an incoming TBM as a simple unitary high explosive payload or a weapon of mass destruction/casualty. An unengaged weapon of mass destruction would have far more devastating effects than even the tragic loss of life seen in the military barracks near Dhahran [Saudi Arabia]. How devastating would an engaged TBM-delivered weapon of mass destruction have been? The more relevant question to the air defense material developer is 'How lethal does my defense weapon have to be?'

Current air defense Operational Requirement Documents (ORDs) require the highest interceptor lethality possible, partly due to the current inability to reliably estimate the effects on defended assets from partially destroyed payloads, and high lethality requirements drive up interceptor complexity and cost.

To date, extensive work has been done to determine Pk contours and end game environments, etc. However, little effort has been expended to relate the defended asset dynamic effectiveness against various weapon delivery systems and payloads to the air defense system performance.

The cooperative analysis of lethality and mission effectiveness, funded by Project Manager for the Corps Surface-to-Air Missile (PM CORPS SAM), will provide a means to evaluate the defense mission effectiveness for interceptors of varying lethality, deployment strategies for assets and defense components, and engagement strategies for weapon systems.

## 2. OBJECTIVE

The objective of the PM CORPS SAM-funded work is to provide a common basis for determining the lethality requirements for the Medium Extended Air Defense System (MEADS). MEVATEC Corporation, a contractor to PM CORPS SAM, has been running the Army Unit Resiliency Analysis (AURA) program for several years. During this time MEVATEC has also been modifying source code

to address the company's specific problems. One of the portions of AURA code which MEVATEC modified was the "All Clear" algorithm. This is the algorithm that deals with the problem of vapor cloud drift and assesses when personnel can revert to their original mission-oriented protective posture (MOPP). The objective of this task was to review both the original Army Research Laboratory (ARL) algorithm and the modified MEVATEC algorithm and then to recommend any changes that ARL felt were necessary.

### 3. APPROACH

A methodology that links a force engagement simulation in a serial fashion with a lethality, atmospheric/ground transport, and unit effectiveness will be used to evaluate the dynamic effectiveness of the defended asset as a function of defense mission effectiveness. The Naval Surface Warfare Center (NSWC) Vapor, Liquid, Solid Tracking (VLSTRACK) agent transport simulation and the AURA computer simulation model, developed by ARL, and the Submunition Laydown Pattern Predictor (SLPP) propagation model will form the basis for this linkage.

### 4. SCOPE

The implementation of this methodology will require modifications to the AURA model and general support for questions that arise. MEVATEC, PM CORPS SAM's contractor, will modify the AURA code, with ARL acting as consultants.

This task involves the review of the updated "All Clear" algorithm within AURA. The AURA All Clear algorithm was modified to account for cases with large (with respect to asset size) vaporous agent clouds (i.e., primarily dosage with little or no deposition). In these cases, it was found that the original algorithm gave an unrealistically early "all clear" to come out of mission-oriented protective posture, level 4 (MOPP IV). The problem grew when effects of this shortfall were included. ARL was tasked to review the modifications made to the algorithm, assess the validity, and provide a report on the assessment with recommended changes if necessary.

## 5. PROBLEM

MEVATEC Corporation's modifications to the original ARL Survivability/Lethality Analysis Directorate (SLAD)/Ballistic Vulnerability/Lethality Division (BVLD) All Clear algorithm are confined to finding the largest extent of the threat cloud and then setting the XTENT variable to the greater of the two (largest extent of the unit or the largest extent of the threat cloud). The largest extent is then used to calculate TDRFT—the maximum time, in minutes, which might be required for the toxic cloud to drift across the unit. TDRFT is found by dividing XTENT by the windspeed (with units of meters per minute). XTENT has units of meters, and TDRFT has units of minutes.

The All Clear algorithm is coded in the CLDTIM.f subroutine. ARL's original version of this subroutine can be found in Appendix A, and MEVATEC's modified version of this routine can be found in Appendix B.

It needs to be noted that in MEVATEC's additions to the CLDTIM.f subroutine, where XTENT and TDRFT are calculated, a search is performed on the x and y arrays of the cloud grid Cartesian coordinates (XVPR and YVPR). The maximum and minimum corresponding x and y coordinates are determined. The Pythagorean theorem is then used to find the length of the diagonal that connects these points (XTENTV). What is important here is that these calculations are based solely on the rectangular Cartesian coordinates of the cloud grid only. During this procedure, there is no accounting for cloud values of zero within the grid. Clouds usually take on an elliptical shape as the material is transported downwind. The orientation of this elliptical shape is with the major axis following the wind direction. The elliptical cloud is characterized by a two-dimensional rectangular grid. The diagonal (XTENTV) is the distance that the opposite corners of the full rectangular grid are from one another. A good percentage of the distance may be over areas where the cloud measure value is zero and where much of the area will never be affected by the cloud.

As far as the past use of the All Clear signal when dealing with liquid agents goes, during SLAD's study of the Corps Main Command Post (CMCP) performed in FY94, the assumption was made that the minimum time for the All Clear, from liquid agent, to be declared was a minimum of 30 min plus the evaporation time of the agent (or persistence time). Doctrine calls for at least two negative testing procedures with the M8 chemical agent detection paper to have taken place. The time required to

complete a testing procedure, again according to doctrine, is 15 min, and with two sweeps required, a minimum of 30 min total was used.

## 6. SOLUTION

A better approximation for the maximum extent of a cloud which will have to transverse the unit area is simply the maximum downwind (x direction) length of the cloud. Using the diagonal not only artificially inflates this distance by using the areas of zero cloud effect, but it also seems to assume that the wind direction can vary—hence, the crosswind component used to create the diagonal. Currently, the wind direction and speed are fixed throughout the analysis. The wind speed is one of the major driving factors behind the transport and diffusion of the cloud. In the case of the cloud being larger than the asset, the only time the cloud extent is used, there are two possible cloud/unit configurations when the agent source occurs upwind of the asset:

- (1) The cloud does not overlap the asset, and
- (2) The cloud does overlap the asset.

When the cloud does not overlap the asset, the maximum distance that the cloud may have to travel to clear the unit is the maximum distance across the unit with respect to the wind direction (let's call this "UNITWMAX") plus the maximum of the cloud downwind length (XTENTV) and the downwind distance that the initial source of the cloud (referred to as the "start" of the cloud) is from the upwind edge of the unit (let's call this "CLDOFF").

When the cloud does overlap the asset, the maximum distance a cloud may have to travel to clear the unit is UNITWMAX plus CLDOFF.

One should realize that "large" aerosol or vapor clouds tend to be much longer than they are wide. The longest linear distance covered by the cloud can generally be found along its center line (with respect to the wind direction). If one makes the assumption that PRETOX has bounded the cloud such that the first and last x coordinates of the cloud grid are where the cloud begins and ends, one can develop an algorithm, very similar to that of MEVATEC's, to calculate the maximum extent of the cloud. The array containing the cloud measure grid needs to be accessible to the CLDTIM.f subroutine; this array is

contained in the TOXRNRM common block under the variable name VPRNR. The array containing the asset coordinates is already accessible to the CLDTIM.f subroutine; this array is contained in the CULL common block under the variable name DEPMAX. The array containing the munition impact point coordinates also needs to be accessible to the CLDTIM.f subroutine; this array is contained in the EMPLOY common block under the variable name DGZ. The wind angle variables (ANGWND, COSWND, and SINWND) are members of the WNDANG common block; this also needs to be accessible to the CLDTIM.f subroutine. Also, an assumption central to the construction of the algorithm present is that the asset center is the origin of the Cartesian coordinate system (the zero-zero point), the asset is symmetrical about the origin, and the general shape of the asset is either square or rectangular. The algorithm could be written as follows:

(1) Find the "start" of the cloud (minimum x and corresponding y). Find the y value for the maximum cloud effect value in the first x line of the cloud grid VPRNR.

(2) Find the "end" of the cloud (maximum x and corresponding y). Find the y value for the maximum cloud effect value in the last x line of the cloud grid VPRNR.

(3) Use Pythagorean's theorem and the points found in 1 and 2 to find the total extent (XTENT) of the cloud.

(4) Find the total extent of the asset with respect to the wind direction (UNITWMAX).

- Determine the angle the unit diagonal makes with the x axis (ANGDIA).

$$\text{ANGDIA} = \text{INV TAN}(\text{DEPMAX}(2,2)/\text{DEPMAX}(1,2)).$$

- If  $(\text{ANGDIA} \geq \text{ANGWND})$ , then  $\text{UNITWMAX} = 2 * (\text{DEPMAX}(1,2) / \text{COSWND})$ .
- ELSE  $(\text{ANGDIA} < \text{ANGWND})$  then  $\text{UNITMAX} = 2 * (\text{DEPMAX}(2,2) / (\text{SINWND}))$ .

(5) Find the maximum downwind distance that the "start" of the cloud is from the upwind edge of the unit (CLDOFF). Do for all incoming rounds and pick the one which is the largest.

- $X(I)$  is the x coordinate of the impact of round I.
- $Y(I)$  is the y coordinate of the impact of round I.
- The downwind distance from the impact point to the asset center is DOWND.  $DOWND = X(I)*COSWND + Y(I)*SINWND$ .
- The downwind distance from the impact point to the asset edge is DOWNA.  $DOWNA = DOWND - (0.5*UNITMAX)$ .
- The downwind distance from the "start" of the cloud to the edge of the asset is CLDAD. The  $XX(MIN)$  is the minimum x found in 1; this is the distance from the round function point to the "start" of the cloud (cloud ground touch down).  $CLDAD = DOWNA - XX(MIN)$ .

## 7. CONCLUSION/RECOMMENDATION

A review of the updated All Clear algorithm within AURA has been completed by ARL. While the modifications made by MEVATEC were found to be valid, ARL recommends that a more robust algorithm be developed.

APPENDIX A:  
ARL'S ORIGINAL CLDTIM.f SUBROUTINE

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```

1      SUBROUTINE CLDTIM
2
3      C THIS SUBROUTINE DEALS WITH THE PROBLEM OF VAPOR CLOUD DRIFT.
4      C THE TIME REQUIRED FOR TOXIC VAPOR TO DRIFT ACROSS THE LONGEST LENGTH
5      C OF THE UNIT IS CALCULATED; TIME = LENGTH OF UNIT/VELOCITY OF WIND.
6      C THIS TIME VALUE IS USED IN THE CALCULATION OF THE
7      C 'PERSISTENCE TIME'. PERSISTENCE TIME IS USED HERE TO REFER
8      C TO THE LENGTH OF TIME THAT A TOXIC HAZARD REMAINS IN THE UNIT
9      C AREA. PERSONNEL DO NO REVERT TO ORIGINAL MOPP POSTURE
10     C UNTIL SOME TIME AFTER THE 'PERSISTENCE' TIME HAS ELAPSED.
11
12     COMMON/CULL/LCULL(2),DEPMAX(2,2),DELMAX(@NWP),TLEMAX
13     COMMON/IO/ IM5,IM6
14     COMMON/LTHTYP/ LCNV, LNUKE, LNUCDN, LTOX, LTOXDN, LNUCDS, LTOXDS,
15     C smart
16     + LSMART
17     LOGICAL LTOX
18     COMMON/RECOOP/ NRECT, TIMGAP, TRECUP(@TIM), TRECON(@TIM)
19     COMMON/TALLY/ NREC, TALTIM(@TIM), LNKWKT(@TIM), LCHNST(@TIM),
20     + EFFREC(@TIM)
21     COMMON/TOXTRM/XTRC(@TW,2),YTRC(@TW,2),XTRP(@TW,2,2),YTRP(@TW,2,2),
22     + XTRV(@TW,2,2),YTRV(@TW,2,2),CTMIN(@TW),CTMAX(@TW),TOXWND(@TW),
23     + CNCXT(@TW),CNCX(@TW),CNCY(@TW),CNCTP(@TW)
24     COMMON/TXCLTH/NTXWPN,NXCNTM(@TW),NTVPR(@TW),NXVPR(@TW),NYVPR(@TW),
25     + NDXTX(@TW,4),XCNTM(@TW,@XTC),TVPR(@TW,10),XVPR(@TW,@XTW),
26     + YVPR(@TW,@YTW),EVPTMX(@TW),PRSTIM(@TW),NYCNTM(@TW),
27     + YCNTM(@TW,@YTW)
28
29     C DETERMINE THE DRIFT TIME OF THE TOXIC CLOUD
30     C AND ADD THIS TO THE PERSISTENCE TIME GIVEN BY NUSSE(TIME FOR
31     C AVERAGE DROPLET TO EVAPORATE.)
32
33     C TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT IS CALCULATED BASED ON
34     C THE RELATIONSHIP: DISTANCE = VELOCITY * TIME.
35     C TDRFT = MAXIMUM LENGTH OF UNIT/VELOCITY OF WIND.
36     C TDRFT IS TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT.
37
38     C LTOX IS LOGICAL SIGNIFYING WHETHER OR NOT THIS IS A TOXIC SCENARIO.
39     C IF THIS IS A TOXIC SCENARIO THEN DO THE FOLLOWING CALCULATION:
40
41     IF( LTOX ) THEN
42
43     C CALCULATE MAXIMUM LENGTH OF THE UNIT BASED ON PYTHAGOREAN THEOREM.
44     C DEPMAX IS ARRAY OF MAXIMA AND MINIMA DEPLOYMENT POINTS.
45     C DEPMAX(1,2) IS THE MAXIMUM VALUE DEPLOYMENT POINT ALONG X AXIS.
46     C DEPMAX(1,1) IS THE MINIMUM VALUE ALONG THE X AXIS.
47     C DEPMAX(2,2) IS THE MAXIMUM VALUE ALONG THE Y AXIS.
48     C DEPMAX(2,1) IS THE MINIMUM VALUE ALONG THE Y AXIS.
49
50     C XTENT IS THE LARGEST EXTENT OF THE UNIT ACROSS WHICH
51     C A TOXIC CLOUD MIGHT TRAVEL
52
53     XTENT = SQRT( (DEPMAX(1,2)-DEPMAX(1,1))**2 +
54     + (DEPMAX(2,2)-DEPMAX(2,1))**2 )
55
56     C DO 24 K = 1, @TW
57     IF( TOXWND(K) .GT. 0.01 ) THEN
58
59     C MULTIPLY TOXWIND BY 60 TO CONVERT FROM SECONDS TO MINUTES.
60     C MINUTES = METERS/[(METERS/SECOND)(60 SECONDS/MINUTE)].
61
62     TDRFT = XTENT / ( TOXWND(K)*60. )
63
64     C IF WIND SPEED IS CLOSE TO ZERO, THEN THERE IS NO DRIFT DOWNWIND,
65     C SO TDRFT IS SET CLOSE TO INFINITE. CLOUD WON'T DRIFT DOWNWIND
66     C AND PERSONNEL WILL BE FORCED TO STAY IN MOPP UNTIL EVAPORATION
67     C OF AGENT. THIS IS VALID FOR THE PERSISTENT AGENT CASE, BUT
68     C NOT FOR A NONPERSISTENT AGENT. A CHECK AND CORRECTION IS
69     C MADE FOR THIS LATER.
70
71     ELSE

```

```

72          TDRFT = 1.E35
73      ENDIF
74  C
75  C   TDRFT IS THE TIME - IN MINUTES - TO DRIFT ACROSS THE
76  C   LARGEST EXTENT OF THE UNIT.
77  C
78  C   PRSTIM CONTAINS THE TIME OF THE FIRST DOSAGE GRID TO
79  C   SHOW NO INCREASES. FOR A PURE LIQUID (NO VAPOR) IT IS 0.
80  C   IF EVERY GRID SHOWED AN INCREASE, IT IS 1.E35. (THE
81  C   AURA ANALYST MUST BE CAREFUL WHEN CHOOSING NUSSE INPUT
82  C   TIMES TO AVOID MODELING AN 'INFINETELY' PERSISTENT
83  C   HAZARD AS A RESULT OF SELECTING TIMES WHICH ARE
84  C   NOT REPRESENTATIVE OF THE LIFETIME OF THE HAZARD.
85  C
86  C   TOTAL PERSISTENCE TIME IS ESTIMATED BY TAKING THIS
87  C   MAXIMUM EVAPORATION TIME AND ADDING THE DRIFT TIME TO IT
88  C   TO ACCOUNT FOR THE SECONDARY EVAPORATION HAZARD OF LIQUID
89  C   AGENT. HOWEVER, THERE IS NO SECONDARY VAPOR HAZARD FOR PURELY
90  C   VAPOR AGENTS.
91  C
92  C   TO CALCULATE TOTAL PERSISTENCE TIME....
93  C
94  C   FOR A LIQUID AGENT:
95  C   ADD EVPTMX, THE EVAPORATION TIME OF A LIQUID AGENT,
96  C   TO THE DRIFT TIME TO DETERMINE THE LENGTH OF TIME A
97  C   HAZARD REMAINS IN THE UNIT AREA.
98  C
99  C       PRSTIM(K) = EVPTMX(K)+TDRFT
100 C
101 C   FOR A VAPOR AGENT: CHECK AGAINST THE POSSIBILITY OF ZERO WIND.
102 C   IF ZERO WIND, THE MAXIMUM PERSISTENCE TIME IS THE MAXIMUM
103 C   NUSSE GRID TIME, TVPR. NTVPR IS THE NUMBER OF TOXIC VAPOR
104 C   WEAPONS. SET QQQ TO THE MAXIMUM OF THE NUSSE
105 C   GRID TIME OR THE EVAPORATION TIME OF A LIQUID AGENT(0 IF
106 C   VAPOR AGENT).
107 C
108 C       IF ( NTVPR(K) .GT. 0 ) THEN
109 C           QQQ = AMAX1(EVPTMX(K),TVPR(K,NTVPR(K)))
110 C       ELSE
111 C           QQQ = EVPTMX(K)
112 C       ENDIF
113 C
114 C   SINCE BOTH PRSTIM AND QQQ ARE UPPER BOUNDS,
115 C   CHOOSE THE LESSER OF THE TWO. THIS PREVENTS THE
116 C   UNIT FROM STAYING IN MOPP AN INFINITE AMOUNT OF TIME
117 C   AFTER A NONPERSISTENT AGENT ATTACK.
118 C
119 C       PRSTIM(K) = AMIN1(PRSTIM(K),QQQ)
120 C
121 C   FINALLY, WARN USER IF PERSISTENCE TIME EXCEEDS ENCOUNTER LENGTH.
122 C   TALTIM IS AN ARRAY OF RECONSTITUTION TIMES.
123 C   NRECT IS NUMBER OF RECONSTITUTION TIMES.
124 C
125 C       IF( PRSTIM(K) .GT. TALTIM(NRECT) ) THEN
126 C           WRITE(IM6,69) PRSTIM(K),K,TALTIM(NRECT)
127 69      FORMAT(' *** WARNING *** PERSISTENCE TIME (',F10.2,
128 +          ' ) OF TOXIC WEAPON DISPERSION # ',I4,' IS LONGER THAN',
129 +          ' ENCOUNTER TIME (',F10.2,' )',/
130 +          ' ONCE INTO MOPP, PERSONNEL WILL NOT GET OUT.' )
131 C           WRITE(1,69) PRSTIM(K),K,TALTIM(NRECT)
132 C       ENDIF
133 24      CONTINUE
134      ENDIF
135      RETURN
136      END

```

APPENDIX B:  
MEVATEC'S CLDTIM.f SUBROUTINE

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```

1      SUBROUTINE CLDTIM
2
3      C
4      C THIS SUBROUTINE DEALS WITH THE PROBLEM OF VAPOR CLOUD DRIFT.
5      C THE TIME REQUIRED FOR TOXIC VAPOR TO DRIFT ACROSS THE LONGEST LENGTH
6      C OF THE UNIT IS CALCULATED; TIME = LENGTH OF UNIT/VELOCITY OF WIND.
7      C THIS TIME VALUE IS USED IN THE CALCULATION OF THE
8      C 'PERSISTENCE TIME'. PERSISTENCE TIME IS USED HERE TO REFER
9      C TO THE LENGTH OF TIME THAT A TOXIC HAZARD REMAINS IN THE UNIT
10     C AREA. PERSONNEL DO NO REVERT TO ORIGINAL MOPP POSTURE
11     C UNTIL SOME TIME AFTER THE 'PERSISTENCE' TIME HAS ELAPSED.
12
13     COMMON/CULL/LCULL(2),DEPMAX(2,2),DELMAX(50),TLEMAX
14     COMMON/IO/ IM5,IM6
15     COMMON/LTHTYP/ LCNV, LNUKE, LNUCDN, LTOX, LTOXDN, LNUCDS, LTOXDS
16     LOGICAL LTOX
17     COMMON/RECOOP/ NRECT, TIMGAP, TRECUP(20), TRECON(20)
18     COMMON/TALLY/ NREC,TALTIM(20),LNKWKT(20),LCHNST(20),
19     + EFFREC(20)
20     COMMON/TOXTRM/XTRC(13,2),YTRC(13,2),XTRP(13,2,2),YTRP(13,2,2),
21     + XTRV(13,2,2),YTRV(13,2,2),CTMIN(13),CTMAX(13),TOXWND(13),
22     + CNCXT(13),CNCX(13),CNCY(13),CNCTP(13)
23     COMMON/TXCLTH/NTXWPN,NXCNTM(13),NTVPR(13),NXVPR(13),NYVPR(13),
24     + NDXTX(13,4),XCNTM(13,176),TVPR(13,10),XVPR(13,300),
25     + YVPR(13,99),EVPTMX(13),PRSTIM(13),NYCNTM(13),
26     + YCNTM(13,50)
27
28     C
29     C DETERMINE THE DRIFT TIME OF THE TOXIC CLOUD
30     C AND ADD THIS TO THE PERSISTENCE TIME GIVEN BY NUSSE(TIME FOR
31     C AVERAGE DROPLET TO EVAPORATE.)
32
33     C
34     C TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT IS CALCULATED BASED ON
35     C THE RELATIONSHIP: DISTANCE = VELOCITY * TIME.
36     C TDRFT = MAXIMUM LENGTH OF UNIT/VELOCITY OF WIND.
37     C TDRFT IS TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT.
38
39     C
40     C LTOX IS LOGICAL SIGNIFYING WHETHER OR NOT THIS IS A TOXIC SCENARIO.
41     C IF THIS IS A TOXIC SCENARIO THEN DO THE FOLLOWING CALCULATION:
42
43     C
44     C IF( LTOX ) THEN
45
46     C
47     C CALCULATE MAXIMUM LENGTH OF THE UNIT BASED ON PYTHAGOREAN THEOREM.
48     C DEPMAX IS ARRAY OF MAXIMA AND MINIMA DEPLOYMENT POINTS.
49     C DEPMAX(1,2) IS THE MAXIMUM VALUE DEPLOYMENT POINT ALONG X AXIS.
50     C DEPMAX(1,1) IS THE MINIMUM VALUE ALONG THE X AXIS.
51     C DEPMAX(2,2) IS THE MAXIMUM VALUE ALONG THE Y AXIS.
52     C DEPMAX(2,1) IS THE MINIMUM VALUE ALONG THE Y AXIS.
53
54     C
55     C XTENTV IS THE LARGEST EXTENT OF THE CLOUD
56
57     C
58     XMIN = 1.0E10
59     XMAX = -1.0E10
60     YMIN = 1.0E10
61     YMAX = -1.0E10
62
63     DO 995 K = 1,13
64     DO 996 J = 1,NXVPR(K)
65     XMIN = AMIN1(XMIN,XVPR(K,J))
66     XMAX = AMAX1(XMAX,XVPR(K,J))
67     996 CONTINUE
68     DO 995 J = 1,NYVPR(K)
69     YMIN = AMIN1(YMIN,YVPR(K,J))
70     YMAX = AMAX1(YMAX,YVPR(K,J))
71     995 CONTINUE
72     XTENTV = SQRT((XMAX - XMIN)**2 +
73     + (YMAX - YMIN)**2 )
74
75     C
76     C XTENT IS THE LARGEST EXTENT OF THE UNIT ACROSS WHICH
77     C A TOXIC CLOUD MIGHT TRAVEL
78
79     C
80     XTENT = SQRT( (DEPMAX(1,2)-DEPMAX(1,1))**2 +
81     + (DEPMAX(2,2)-DEPMAX(2,1))**2 )

```

```

72      C   XTENT IS THE GREATER OF THE DIAGONAL OF THE CLOUD VERSUS
73      C   THE DIAGONAL OF THE UNIT
74
75      XTENT = AMAX1(XTENT,XTENTV)
76
77      C
78      DO 24 K = 1, 13
79      IF( TOXWND(K) .GT. 0.01 ) THEN
80      C   MULTIPLY TOXWIND BY 60 TO CONVERT FROM SECONDS TO MINUTES.
81      C   MINUTES = METERS/[(METERS/SECOND)(60 SECONDS/MINUTE)].
82      C
83      TDRFT = XTENT / ( TOXWND(K)*60. )
84
85      C   IF WIND SPEED IS CLOSE TO ZERO, THEN THERE IS NO DRIFT DOWNWIND,
86      C   SO TDRFT IS SET CLOSE TO INFINITE. CLOUD WON'T DRIFT DOWNWIND
87      C   AND PERSONNEL WILL BE FORCED TO STAY IN MOPP UNTIL EVAPORATION
88      C   OF AGENT. THIS IS VALID FOR THE PERSISTENT AGENT CASE, BUT
89      C   NOT FOR A NONPERSISTENT AGENT. A CHECK AND CORRECTION IS
90      C   MADE FOR THIS LATER.
91      C
92      ELSE
93      TDRFT = 1.E35
94      ENDIF
95
96      C   TDRFT IS THE TIME - IN MINUTES - TO DRIFT ACROSS THE
97      C   LARGEST EXTENT OF THE UNIT.
98
99      C   PRSTIM CONTAINS THE TIME OF THE FIRST DOSAGE GRID TO
100     C   SHOW NO INCREASES. FOR A PURE LIQUID (NO VAPOR) IT IS 0.
101     C   IF EVERY GRID SHOWED AN INCREASE, IT IS 1.E35. (THE
102     C   AURA ANALYST MUST BE CAREFUL WHEN CHOOSING NUSSE INPUT
103     C   TIMES TO AVOID MODELING AN 'INFINETELY' PERSISTENT
104     C   HAZARD AS A RESULT OF SELECTING TIMES WHICH ARE
105     C   NOT REPRESENTATIVE OF THE LIFETIME OF THE HAZARD.
106
107     C   TOTAL PERSISTENCE TIME IS ESTIMATED BY TAKING THIS
108     C   MAXIMUM EVAPORATION TIME AND ADDING THE DRIFT TIME TO IT
109     C   TO ACCOUNT FOR THE SECONDARY EVAPORATION HAZARD OF LIQUID
110     C   AGENT. HOWEVER, THERE IS NO SECONDARY VAPOR HAZARD FOR PURELY
111     C   VAPOR AGENTS.
112
113     C   TO CALCULATE TOTAL PERSISTENCE TIME....
114
115     C   FOR A LIQUID AGENT:
116     C   ADD EVPTMX, THE EVAPORATION TIME OF A LIQUID AGENT,
117     C   TO THE DRIFT TIME TO DETERMINE THE LENGTH OF TIME A
118     C   HAZARD REMAINS IN THE UNIT AREA.
119
120     PRSTIM(K) = EVPTMX(K)+TDRFT
121
122     C   FOR A VAPOR AGENT: CHECK AGAINST THE POSSIBILITY OF ZERO WIND.
123     C   IF ZERO WIND, THE MAXIMUM PERSISTENCE TIME IS THE MAXIMUM
124     C   NUSSE GRID TIME, TVPR. NTVPR IS THE NUMBER OF TOXIC VAPOR
125     C   WEAPONS. SET QQQ TO THE MAXIMUM OF THE NUSSE
126     C   GRID TIME OR THE EVAPORATION TIME OF A LIQUID AGENT(0 IF
127     C   VAPOR AGENT).
128
129     IF ( NTVPR(K) .GT. 0 ) THEN
130     QQQ = AMAX1(EVPTMX(K),TVPR(K,NTVPR(K)))
131     ELSE
132     QQQ = EVPTMX(K)
133     ENDIF
134
135     C   SINCE BOTH PRSTIM AND QQQ ARE UPPER BOUNDS,
136     C   CHOOSE THE LESSER OF THE TWO. THIS PREVENTS THE
137     C   UNIT FROM STAYING IN MOPP AN INFINITE AMOUNT OF TIME
138     C   AFTER A NONPERSISTENT AGENT ATTACK.
139
140     PRSTIM(K) = AMIN1(PRSTIM(K),QQQ)
141
142     C   FINALLY, WARN USER IF PERSISTENCE TIME EXCEEDS ENCOUNTER LENGTH.

```

```

143      C TALTIM IS AN ARRAY OF RECONSTITUTION TIMES.
144      C NRECT IS NUMBER OF RECONSTITUTION TIMES.
145      C
146          IF( PRSTIM(K) .GT. TALTIM(NRECT) ) THEN
147              WRITE(IM6,69) PRSTIM(K),K,TALTIM(NRECT)
148      69      FORMAT('0*** WARNING *** PERSISTENCE TIME (' ,F10.2,
149          +      ' ) OF TOXIC WEAPON DISPERSION # ' ,I4, ' IS LONGER THAN',
150          +      ' ENCOUNTER TIME (' ,F10.2, ' )', /
151          +      ' ONCE INTO MOPP, PERSONNEL WILL NOT GET OUT.' )
152              WRITE(1,69) PRSTIM(K),K,TALTIM(NRECT)
153          ENDIF
154      24      CONTINUE
155      ENDIF
156      RETURN
157      END

```

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